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Spectra, Thresholds, and Modal Fields of a Triangular Microcavity Laser

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Abstract

© 2018 IEEE. We study the modes of a triangular microcavity laser, namely the frequencies of emission, threshold values of gain, and mode field patterns, within the classical electromagnetics approach. Our instrument is the accurate formalism of Lasing Eigenvalue Problem (LEP), i.e. boundary-value problem with full set of the boundary and radiation conditions. The LEP is reduced to a nonlinear eigenvalue problem for the Muller integral equation on the cavity's boundary. Discretizing it with a Nyström approximation of weakly singular integral operators, we obtain a characteristic equation for the mode frequencies and thresholds.

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Keywords

lasing eigenvalue problem, microcavity laser, Muller boundary integral equation, Nyström method

References

[1] M. Lebental, E. Bogomolny, and J. Zyss, Organic micro-lasers: A new avenue onto wave chaos physics, in A. B. Matsko (Ed.) Practical Applications of Microresonators in Optics and Photonics, CRC Press, Roca Baton, pp. 317-353, 2009.

[2] E. I. Smotrova, A. I. Nosich, T. M. Benson, and P. Sewell, Cold-cavity thresholds of microdisks with uniform and non-uniform gain: quasi-3D modeling with accurate 2D analysis, IEEE J. Sel. Topics Quant. Electron., vol. 11, pp. 1135-1142, 2005.

[3] E. I. Smotrova, V. Tsvirkun, I. Gozhyk, C. Lafargue, C. Ulysse, M. Lebental, and A. I. Nosich, Spectra, thresholds, and modal fields of a kite-shaped microcavity laser, J. Opt. Soc. Am. B, vol. 30, no 6, pp. 1732-1742, 2013.

[4] I. O. Sukharevsky, A. I. Nosich, and A. Altintas, Manipulation of backscattering from a dielectric cylinder of triangular cross-section using the interplay of GO-like ray effects and resonances, IEEE Trans. Antennas Propagat., vol. 63, no 5, pp. 2162-2169, 2015.

[5] E. Karchevskii and A. Nosich, Methods of analytical regularization in the spectral theory of open waveguides, Proc. Int. Conf. Math. Methods in EM Theory (MMET2014), Dnipropetrovsk, 2014, pp. 39-45.

[6] A. I. Nosich, Method of analytical regularization in computational photonics, Radio Science, vol. 51, no 8, pp. 1421-1430, 2016.

[7] A. O. Spiridonov, E. M. Karchevskii and A. I. Nosich, Spectra, thresholds, and modal fields of a circular microcavity laser transforming into a square, Proc. Int. Conf. Transp. Opt. Networks (ICTON-2015), 2015, art. no 7193654.

[8] A. O. Spiridonov and E. M. Karchevskii, Field patterns of whisperinggallery and bow-tie modes of elliptic microcavity laser with a circular active region, Proc. Int. Conf. Transp. Opt. Networks (ICTON-2016), 2016, art. no. 7550639.

[9] A. S. Zolotukhina, A. O. Spiridonov, E. M. Karchevskii, and A. I. Nosich Lasing modes of a microdisk with a ring gain area and of an active microring, Opt. Quant. Electron., vol. 47, no. 12, pp. 3883-3891, 2015.

[10] A. S. Zolotukhina, A. O. Spiridonov, E. M. Karchevskii, and A. I. Nosich, Electromagnetic analysis of optimal pumping of a microdisk laser with a ring electrode, Appl. Physics B., vol. 123, art. no. 32, 2017.

[11] A. O. Spiridonov, E. M. Karchevskii, and A. I. Nosich, Symmetry accounting in the integral-equation analysis of the lasing eigenvalue problems for two-dimensional optical microcavities, J. Opt. Soc. Am. B, vol. 34, pp. 1435-1443, 2017.

[12] A. O. Spiridonov and E. M. Karchevskii, Mathematical and numerical analysis of the spectral characteristics of dielectric microcavities with active regions, Proc. Int. Conf. Days on Diffraction (DD-2016), 2016, pp. 390-395.

[13] O. V. Shapoval, K. Kobayashi, and A. I. Nosich, Electromagnetic engineering of a single-mode nanolaser on a metal plasmonic strip placed into a circular quantum wire, IEEE J. Sel. Topics Quant. Electron., vol. 23, no 6, art no 1501609, 2017.

[14] S. Steinberg, Meromorphic families of compact operators, Ar. Rat. Mech. An., vol. 31, pp. 372-379, 1968.

[15] W. G. Bickley, Two-dimension potential problems concerning a single closed boundary, Phil. Trans., vol. 228, pp 235-273, 1929.

[16] I. O. Sukharevsky, M. Lebental, B. Dietzc, C. Lafargue, and S. Bittner, Dielectric equilateral triangle microresonators: Integral equations and semiclassical physics approaches, Proc. SPIE, vol. 10518, art. no 105181U-1, 201

[17] Y.-Z. Huang, Q. Chen, W.-H Guo, Q.-Y. Lu, and L.-J Yu, Mode characteristics for equilateral triangle optical resonators, lEEE J. Sel. Top. Quant. Electron., vol. 12, no 1, pp. 59-65, 2006.